

WRIA 14

Kennedy-Goldsborough Watershed Water Storage Assessment

Prepared under Ecology Watershed Grant G0400366 for:

**WRIA 14 Planning Unit
Courthouse Building 1
411 North Fifth Street
P.O. Box 279
Shelton, Washington 98584**

By
**Cosmopolitan Engineering Group
and
RH2 Engineering, Inc.**

December 2005

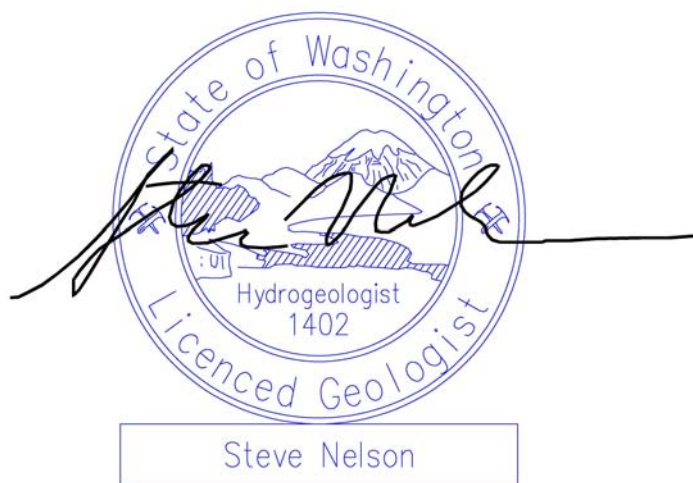


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EXECUTIVE SUMMARY

The Kennedy-Goldsborough WRIA 14 Planning Unit is developing a Watershed Management Plan under RCW 90.82. This Phase II Level 2 water storage assessment and a concurrent Phase II Level 2 Assessment of hydrogeologic conditions of the area northeast of Shelton will provide scientific and technical information necessary for understanding and managing the surface water and groundwater resources in this portion of WRIA 14.

The Shelton Area Regional Plan proposes to generate approximately 0.3 to 0.6 million gallons per day (MGD) of Class A reclaimed water at a satellite WWTP near Sanderson Field. This water may be used for non-potable uses, discharged to the environment, or both. This storage assessment evaluates the potential benefits and impacts of the largest proposed infiltration and storage project in WRIA 14.

The storage assessment area is underlain by Tertiary-age basalt, siltstone and sandstone bedrock. Unconsolidated sand, gravel, and silt were deposited upon bedrock by alluvial and glacial processes during and between recurring glacial episodes of the past several million years. Precipitation rapidly infiltrates and recharges shallow groundwater. Deeper groundwater is recharged from outside the assessment area. Groundwater in shallow sand and gravel units flows towards and discharges laterally into wetlands and streams. The rate and volume of groundwater flow through the shallow subsurface varies widely due to the complexity of hydrostratigraphy units in the assessment area. Low permeability units generally impede (limit) vertical seepage into deeper aquifers. Where the low permeability units are thin or absent, vertical seepage from shallow aquifers may contribute recharge to underlying aquifers.

Groundwater supply for the largest users in the assessment area primarily derives from deep and/or distant sources of recharge. Shallow groundwater from the uppermost unconfined aquifer may contribute a portion of recharge to deeper water supply aquifers where low permeability layers are thin or absent. Surface water flows in streams typically exceed 10 cubic feet per second (cfs). In comparison, the 0.93 cfs of reclaimed water generated by the Regional Plan is small relative to local demands for groundwater and surface water. However, introducing a 0.93 cfs flow of reclaimed water to the environment is a measurable benefit to increase stream flow or offset groundwater demand. Potential impacts of infiltrating the reclaimed water may include increased water levels on natural systems, adverse impacts to groundwater quality, reduction of water recharge at discontinued wastewater systems, or impaired functions of existing land uses or critical areas.

The infiltration and aquifer characteristics of shallow sand and gravel units are similar throughout the storage assessment area. Seven distinct hydrogeologic and hydrologic regions were identified that associate shallow groundwater discharge and a receiving surface water body. The delineation of the infiltration sub-basins supports the selection of preferred locations for infiltration and storage projects in the assessment area.

The Sanderson Field-Fairgrounds area and the Port of Shelton Industrial Park were considered the two areas with highest potential benefits from reclaimed water discharge. Infiltration and aquifer testing results confirmed both the high infiltration rates and limited groundwater mounding potential for these areas. Additional evaluation of the infiltration and groundwater mounding potential of the Upper Goldsborough Creek sub-basin also

indicated favorable conditions and benefits for reclaimed water infiltration and storage at the WCC sprayfield area.

Design and operation of a reclaimed water infiltration facility will depend on the site-specific hydrogeologic conditions. Additional subsurface exploration and infiltration pilot testing would confirm the findings of this assessment and support the design of an infiltration system at the selected site. Additional groundwater and surface water monitoring will assess the benefits and impacts at the selected location of the infiltration and storage system.

Subsurface infiltration trenches, rather than open ponds, to apply water to the shallow subsurface would likely provide the greatest operational control and flexibility, lowest potential for groundwater mounding, and greatest potential for public acceptance. The network of piping and trenches could be constructed to meet the initial loading rate and then expand as loading increased or with changes in groundwater storage beneath the facility.

1. INTRODUCTION

Purpose

This water storage assessment for the Kennedy-Goldsborough WRIA 14 (Watershed Resource Inventory Area) in Mason County (**Figure 1.1**) was completed under the Washington Department of Ecology (Ecology) Water Storage Grant G040036 following RCW 90.82.040. The assessment evaluated regional and local hydrogeologic characteristics that would influence reclaimed water infiltration projects near the City of Shelton, the potential benefits and impacts of reclaimed water discharge from the proposed Shelton Area Regional Plan (the Regional Plan), pertinent regulations that would govern reclaimed water infiltration, storage and reuse, and a preliminary review of the technical and regulatory requirements for designing and operating a reclaimed water infiltration facility near Shelton.

Background

The WRIA 14 Planning Unit is developing a Watershed Management Plan under RCW 90.82. The plan will partially incorporate the findings and recommendations of a Phase II - Level 1 Assessment of regional hydrologic and hydrogeologic characteristics of the watershed (Golder Associates, 2003), a Phase II Level 2 Assessment of hydrogeologic conditions of a 60-square mile area near Shelton (Northwest Land and Water, Inc., 2005), and this Phase II Level 2 water storage assessment. The watershed plan will provide the scientific and technical information with recommendations for managing the surface water and groundwater resources of WRIA 14.

Ecology funds Water Storage Grants to assess multipurpose water storage operations within a watershed. The funding may be used to: 1) investigate the opportunities for one or several methods for water storage, resulting in a detailed conceptual understanding of the benefits/impacts of potential storage opportunities to guide future storage projects; or 2) study one or more specific storage projects planned or considered for implementation within the watershed resulting in analysis of benefits/impacts of specific storage projects. The proposed Regional Plan for wastewater reuse is the most significant new storage/reuse project planned for the watershed¹. The WRIA 14 Planning Unit selected to use the storage grant to evaluate the environmental conditions, potential benefits and potential impacts of discharging reclaimed water generated by the proposed Regional Plan into the environment by subsurface infiltration.

Regional Plan Wastewater Reuse Project

One of the main objectives of the Regional Plan is to ensure environmentally responsible growth by improving current wastewater treatment operations in the area. The Regional Plan would include modification of and upgrades to existing wastewater projects, including:

- Closure of Port of Shelton and Washington State Patrol septic drain field(s).

¹ The North Bay/Case Inlet reclaimed water facility in Allyn at the northeast corner of WRIA 14 disposes of approximately 300,000 gallons of Class A water per day via surface percolation (http://www.ecy.wa.gov/programs/wq/permits/permit_pdfs/north_bay_case/north_bay-case_inlet_fact_sheet.pdf). The Squaxin Tribe is considering treatment alternatives for a wastewater facility near Kamilche which may include a reclaimed water reuse component. The Tribe is in the process of selecting a consultant to design the required WWTP upgrades, including treatment to Class A reclaimed water standards for reuse.

- Decommissioning the Washington Department of Corrections WWTP (wastewater treatment plant) and potentially upgrading the wastewater sprayfield.
- Upgrading the existing City of Shelton wastewater treatment plant.
- Construction of a satellite wastewater treatment plant (Regional Plan Alternative).
- Construction of a wastewater reuse system near the Sanderson Field (Mason County) airport (Regional Plan Alternative).
- Distribution of reclaimed water for multiple non-potable uses (Regional Plan Alternative).
- Infiltration of reclaimed water into the shallow subsurface (Regional Plan Alternative).

The Regional Plan would generate approximately 0.3 to 0.6 millions of gallons per day (MGD) of Class A reclaimed water at a satellite WWTP near Sanderson Field (**Figure 1.2**). This water may be used for non-potable uses, discharged to the environment, or both. Following preliminary screening of practicability and regulatory compliance, the Regional Planning Board concluded that the proposed WWTP site is optimally located for treatment/reuse/storage. Recharging Class A water to aquifers potentially increases instream flow, enhances habitat, and increases groundwater reserves. Evaluation of the project feasibility includes preparing an Environmental Report to assess the environmental impacts of the water reuse. This Report mirrors the watershed planning requirement for environmental assessment of water storage/reuse. Therefore, the watershed management grant funding for storage assessment and the Regional Plan Environmental Report complement and reinforce mutual objectives. Pooling the funding and technical resources will accelerate and improve the water storage/reuse assessment.

The water storage assessment was developed concurrently with the hydrogeologic investigation. The water storage assessment evaluated the hydrogeologic characteristics of proposed infiltration sites and aquifer storage areas and the surrounding environment that would potentially benefit or be impaired by the infiltration and groundwater recharge. **Figure 1.1** shows the water storage assessment area and the hydrogeologic investigation area.

Objectives

The water storage assessment:

- Evaluated the local hydrogeologic characteristics of the potential reuse site(s) and surrounding areas (see **Figure 1.1**).
- Determined the feasible range and method of reuse water infiltration application rates.
- Identified the potential environmental benefits of infiltrating reclaimed water to the shallow aquifers in the assessment area.
- Identified the potential environmental impacts of reclaimed water infiltration and storage.

- Compared benefits and impacts between different locations with adequate significant infiltration and storage potential.
- Identified preferred locations within the assessment area for reclaimed water infiltration and storage.
- Reviewed pertinent regulations for reclaimed water reuse and discharge.
- Discussed technical and implementation issues that would support infiltration system at the preferred locations.

Setting of the Storage Assessment Area

The WRIA 14 Phase II Level 1 Assessment (Golder, 2003) described the physical setting and water resources of the watershed (**Figure 1.1**) and compiled, organized and summarized existing water resource and land use data. Level 2 Assessments, such as this storage assessment and the hydrogeologic investigation, obtain new water resource information and interpret existing information to improve the conceptual understanding of the water resources in the watershed. Northwest Land and Water, Inc. (NWLW) is currently investigating hydrogeologic conditions in selected areas of WRIA 14 as part of a Level 2 assessment. This storage assessment incorporates some of the findings of the Level 1 Assessment; data generated by NWLW; and results of hydrogeologic investigations conducted for the storage assessment. Additional data sources include published soil and geologic maps (Molenaar and Noble, 1970; Schasse et al., 2003), water well information recorded with Ecology and geotechnical and environmental site investigations completed in the assessment area. This storage assessment assembles the findings of these previous and current studies into the hydrogeologic conceptual model of the assessment area (**Figure 1.2**).

Physiography and Climate

The water storage assessment area lies primarily within the Goldsborough Creek sub-basin of WRIA 14 (**Figure 1.2**). Glacial erosion and depositional features modified by stream erosion have created the current landscape. Northeast-to-southwest-trending ridges form highlands surrounded by relatively flat prairies that rise step-like from Oakland Bay including Johns Prairie northeast and east of Shelton and McEwen Prairie north of Sanderson Field (**Figure 1.3**). Topographic relief directs surface water runoff towards Goldsborough Creek, Johns Creek and Shelton Creek – the three primary streams in the assessment area, which flow in shallow channels through broad valleys in the higher prairies and cut deeper channels as they approach Oakland Bay (**Figure 1.3**). Lakes and wetlands form in depressions on highlands and prairies, and along the edge between highlands and prairies.

Precipitation records indicate that during 1980 to 2000, annual rainfall in the assessment area ranged from 55 to 75 inches, and averaged 65 inches (National Oceanic Atmospheric Administration data) at Shelton. Precipitation falling primarily during mild and wet winters infiltrates into soil and replenishes groundwater storage in shallow aquifers in the assessment area. Groundwater discharging from surficial and shallow groundwater systems supports stream flow. Little or no snowpack augments surface water flow; shallow groundwater discharging as baseflow comprises most of the stream flow in the assessment area in late summer and fall.

Second-growth fir and hemlock, deciduous alder and maple, and low shrubs and grasses typical of the Puget Sound lowland cover undeveloped land. Elevations in the assessment area range from sea level to 350 feet (**Figure 1.3**).

Land Use and Population Density

WRIA 14 and the storage assessment area supports a wide range of urban and rural uses (**Figure 1.4**) including municipal, commercial, industrial, residential, agricultural, fisheries, mining (gravel), timber, utility transmission and transportation (roads, airport, seaport, rail). Existing land uses and environmental conditions will constrain the location of water storage projects. Goldsborough and Johns Creek provide salmon habitat, and Oakland Bay supports shellfish habitat. A closed regional landfill and a few hazardous waste sites within the storage assessment area have regulatory setbacks that would affect the location and/or operation of potential water storage projects. Mason County Critical Areas Ordinances restrict or exclude certain types of activities in the county, depending on the sensitivity of these areas to manmade influences including artificial infiltration, storage and recovery of reclaimed water. **Figure 1.5** shows some of the significant land uses in the storage assessment area that may affect the siting of a reclaimed water facility.

Population density and the variety of land uses east of Highway 101 greatly exceed those of the area west of Highway 101 (**Figure 1.6**). East of Highway 101, potential impacts of subsurface infiltration of reclaimed water on existing land uses would require additional engineering controls and mitigation not required west of Highway 101.

Surface Water

Surface water in the assessment area flows year-round in Shelton, Goldsborough and Johns Creeks and derives from wet-season precipitation runoff and dry-season groundwater discharge. Continuous stage and flow data from Goldsborough Creek during 1951 to 1971 represents typical stream characteristics for the assessment area (USGS gauge 12076800 in Goldsborough Creek above 7th Street at Shelton, WA). This gauge was reactivated in October 2004 and continuously records stream flow and gauge height.

Stream flow generally correlates to precipitation; peak runoff occurs during November to February, and low base flow occurs during June to September. **Figure 1.7** illustrates the hydrograph for average daily flow in Goldsborough Creek and average daily precipitation for the 1951-1971 period of record. Peak flow in Goldsborough Creek averaged 250 cubic feet per second (cfs) and base flow averaged 25 cfs (10 percent of peak flow). The Squaxin Tribe has installed an additional gauge on Goldsborough Creek at upstream of the USGS gauge at Highway 101. Data for this gauge and the USGS gauge for the October 2004-2005 water year were not available at the time of reporting. Periodic flow data for Johns Creek were measured during 1943 and during 1948-1951 (USGS website - nwis.waterdata.usgs.gov/wa/nwis/discharge/?site_no=12076000). During this period, peak and minimum flow in Johns Creek near Johns Creek Road ranged between 5 and 100 cubic feet per second (cfs) during this period. During 1986 to 1991, Ecology (Ecology, 2005) measured low flows of approximately 10 cfs at the mouth of Johns Creek.

The Squaxin Island Tribe operates a stream gage in Johns Creek at JOH 2 (at Johns Creek Drive) and at JOH 3 (Jensen Road culvert). **Figure 1.7** includes stage data for Johns Creek in 2003-2004. The Squaxin Island Tribe currently conducts surface water and groundwater monitoring in Johns and Goldsborough Creeks to assess stream-aquifer interactions.

Several lakes and wetlands occur in the central prairies of the assessment area (**Figures 1.2 and 1.3**). Island Lake, the largest lake in the area, is surrounded by residences and is used primarily for recreation. Other smaller lakes and associated wetlands have limited human use but support significant wildlife habitat and form natural in-channel storage reservoirs

that attenuate stormwater runoff and discharge to streams. Surface water bodies sensitive to groundwater level fluctuations due to artificial increases in groundwater recharge will constrain the location and operation of water storage projects.

Shelton Springs discharges groundwater into Shelton Creek at rates ranging from 500 to 3,500 gpm, averaging 2,000 gpm (4.4 cfs). The City of Shelton formerly used the springs for municipal supply, but discontinued this use after the Washington Department of Health (DOH) determined that the springs were groundwater under the influence of surface water. Treatment costs to meet DOH regulations made the use of the spring water uneconomical (City of Shelton, personal communication).

2. REGIONAL HYDROGEOLOGIC CHARACTERISTICS OF THE ASSESSMENT AREA

Regional Storage and Infiltration Characteristics of Assessment Area

Geology of the Assessment Area

Sources of information for the geologic characterization of the assessment area include field mapping by the USGS (Molenaar and Noble, 1970) DNR (Schasse et al, 2003), water supply well driller's logs filed with Ecology, and geotechnical, hydrogeologic, and environmental studies that describe local hydrogeologic characteristics of shallow hydrogeologic units in the assessment area (Parametrix, 2003; Ecology, 2004). This assessment included a limited hydrogeologic investigation of the proposed WWTP satellite plant location and the Port of Shelton Industrial Park at Johns Prairie to evaluate infiltration and groundwater mounding potential at these sites. Hydrogeologic characterization of deeper groundwater-bearing zones was completed for the Shelton water supply wells (Robinson and Noble, 1999). NWLW is compiling hydrogeologic information for the area east of the assessment area, primarily in the region surrounding and including Johns Prairie.

The assessment area is underlain by Tertiary-age basalt, siltstone and sandstone bedrock. Unconsolidated sand, gravel, and silt were deposited upon bedrock by alluvial and glacial processes during and between recurring glacial episodes of the past several million years. Glacial processes deposited and modified layers of fine-grained and coarse-grained unconsolidated sediments which vary in thickness and extent in the assessment area. Alluvial processes following each glacial episode eroded, transported and deposited sediment into semi-consolidated layers (Molenaar and Noble, 1970; Schasse et al, 2003) resulting in a complex stratigraphic sequence. **Figure 2.1** illustrates geologic units occurring at the surface in the assessment area.

The shallow unconsolidated geologic materials in the assessment area derive from the most recent (Vashon) glaciation that deposited fine to coarse grained layers of sediment as glacial ice invaded and retreated from Puget Sound. Surficial weathering and alluvial processes have eroded older units and deposited alluvial sediment, primarily along stream channels. The subsequent distribution and hydrogeologic properties of surficial soil and underlying geologic materials control the rate of runoff and infiltration of seasonal precipitation. Hydrogeologic characteristics also control the amount and rate of subsurface storage, direction and rate of groundwater flow, and the timing and rate of groundwater discharge to surface water and Oakland Bay. This storage assessment focuses on the characteristics and extent of the uppermost (approximately 100 feet) of geologic materials which would receive and transmit infiltrated reclaimed water that would be temporarily stored in the shallow geologic units under the Regional Plan. Deeper geologic units likely have significantly less hydraulic connection to shallow groundwater systems in the assessment area (for example, the water-bearing zones in which the City of Shelton derives municipal water supply) are discussed in Robinson and Noble, 1999; NWLW, 2005.

Hydrostratigraphic Units

The characteristics of geologic units in the assessment area can be mapped as distinct units at the surface and, where well completion data are available, can be described in the

subsurface by correlating hydrostratigraphic information available in well logs. This storage assessment and the hydrogeologic investigation by NWLW have identified geologic units on the basis of geologic characteristics and relationships without resorting to the nomenclature of previous studies that interpret the depositional environment and relative age of the units (e.g., pre- or post-glacial) as described in USGS (Molenaar and Noble, 1999) and DNR (Schasse, 2003) studies. This study and NWLW have identified coarse-grained and fine-grained units based on geologic characteristics, hydrostratigraphic relationships and elevation. The storage assessment identifies the following hydrostratigraphic units.

- Unit A – Shallow; coarse-grained, loose sand and gravel; local fine sediment near surface water bodies.
- Unit B – Shallow; dense, fine-grained sand and silt with gravel.
- Unit C – Intermediate depth; fine-grained sand and silt.
- Unit D – Intermediate depth; coarse-grained sand and gravel.
- Deeper Units – Gravel, sand and gravel, sand and silt in various thicknesses (includes Units E and F by NWLW).

Figure 2.1 shows the approximate locations of geologic unit surface exposure. **Figure 2.2** shows generalized geologic cross sections across the assessment area. The cross-section lines are based on well boring logs and interpretations by Robinson and Noble (1999) and NWLW (2005).

Unit A

Unit A occurs as a broad, locally discontinuous layer of unconsolidated sand and gravel with local fine sand and silt layers and is exposed at the surface in approximately 50 percent of the assessment area. Unit A ranges in thickness from 5 to 150 feet, averages 30 to 50 feet thick, and generally thickens towards the south at the Oakland Bay shoreline. Unit A geologic materials were deposited on top of the eroded, undulating surface of Unit B. Unit A fills topographic depressions in the top of underlying Unit B and comprises much of the surficial unit of the upland prairies in the assessment area. Near streams, Unit A consists of relatively thin layers (less than 20 feet) of fine to coarse-grained alluvial sediment. Near lakeshore and wetlands, Unit A consists of fine-grained alluvial, lakebed and organic sediment. In general, Unit A correlates to the recessional outwash and alluvium of Molenaar and Noble (1970). In drillers' logs, Unit A is described as loose sand, sand and gravel, or gravelly sand.

Sand and gravel layers within Unit A are highly permeable, capable of storing and transmitting significant quantities of groundwater, and are a minor source of domestic and irrigation supply, primarily in the McEwen and Johns Prairie areas (**Figure 2.1**). Throughout the assessment area, Unit A exhibits characteristic features of glacial outwash including braided channels and topographic depressions (kettles). The wide-ranging hydraulic conductivity values of aquifer materials associated with these stratigraphic features will affect the rate and flow of groundwater moving through Unit A.

Unit B

Unit B occurs as a broad, continuous layer of dense, consolidated silt and sand with gravel. Unit B ranges in thickness from 5 to 50 feet and averages 25 feet thick. Unit B is interpreted as glacial (Vashon) till and glaciolacustrine sediment that blankets underlying units (Molenaar and Noble, 1970). Erosion-resistant Unit B controls surface topography and forms northeast-southwest trending ridges and valleys oriented in the direction of glacial ice flow (**Figure 1.3**). Unit B forms the higher ridges of the assessment area and underlies much of Unit A in the upland prairies within the assessment area. The very low permeability of Unit B impedes vertical water seepage and likely underlies most of the lakes and wetlands in the assessment area. Driller's logs describe Unit B as "hardpan", gravel with clay and compacted gravel and silt.

Unit C

The base of Unit B may lie in contact with a discontinuous layer of fine-grained sand and sandy silt. This minor unit is interpreted as glaciolacustrine (lakebed) sediment associated with advancing glacier ice. This unit has similar low permeability as overlying glacial till deposits, and may be grouped together with glacial till-like deposits. However, in keeping with the nomenclature selected by NWLW for the hydrogeologic investigation, Unit C is identified as a separate hydrostratigraphic unit in this Report.

The high silt content and density of Units B and C impede vertical infiltration. The units store and transmit limited quantities of groundwater which discharges laterally into Unit A or as seeps along slopes. Groundwater withdrawal from Units B and C is considered insignificant.

Unit D

In the assessment area, Unit D outcrops locally along the bluffs above Oakland Bay and in the Goldsborough Creek valley near Shelton (**Figure 2.1**). NWLW and the Squaxin Tribe are investigating potential surface exposure of Unit D within lower Johns Creek (Squaxin Tribe, pers. comm.) Unit D is described in well logs as gravel and sand with or without minor silt. Unit D is generally encountered in most borings that fully penetrate Units B and C. Deeper borings completed for municipal and industrial supply encountered Unit D thicknesses ranging from 50 to 150 feet. Where coarse-grained sediment underlies Unit D, detailed lithologic inspection of these materials is necessary to define the lower boundary of Unit D with deeper coarse-grained units.

Unit D is moderately to highly permeable and stores and transmits significant quantities of groundwater. Groundwater discharge from Unit D is complex, depending on the hydrostratigraphic relationship with underlying units and topography. NWLW investigated groundwater flow and discharge in Unit D and deeper units in the Johns Prairie area (NWLW, 2005). Beneath the assessment area, most of the groundwater in Unit D likely discharges into Oakland Bay. The majority of private domestic and irrigation supply wells are completed in Unit D, particularly near Island Lake and in the McEwen and Johns Prairies.

Deeper Units

Deeper hydrostratigraphic units underlying Unit D consist of compacted gravel, mixed sand and gravel, and lakebed deposits derived from glacial and alluvial processes. Molenaar and Noble (1970) and Robinson and Noble (1999) describe the character and extent of these units in detail. NWLW (2005) identified two distinct deeper hydrostratigraphic units: 1) a low permeability aquitard (Unit E); and 2) a sand and gravel aquifer (Unit F) that exists at an elevation near sea level. The deeper units are exposed along the lower Goldsborough Creek stream channel (Molenaar and Noble, 1970) and are reported in the lower Johns Creek stream channel (Squaxin Tribe, pers. comm.) Industrial supply wells near the Shelton waterfront were completed in aquifers at a depth of several hundred feet below sea level. These very deep water-bearing units were not considered in either this assessment or by NWLW.

Vertical hydraulic communication between shallower Units A through D and the deeper aquifer occurring at sea level (identified as Unit F by NWLW) is expected to be limited in the storage assessment area. Elsewhere in WRIA 14, primarily near the Oakland Bay shoreline, Units A through D lie closer to sea level and likely experience greater hydraulic communication with the sea level aquifer. This storage assessment focuses on shallower units further inland where potential impacts and benefits of reclaimed water infiltration on shallow groundwater and surface water systems would occur. Thick (more than 100 feet) layers of silt and clay underlie Unit D, hydraulically isolating the shallow units in the assessment area from the deeper aquifer. The impact to deeper units from infiltration and increased storage in shallow groundwater systems, therefore, is considered insignificant. For example, a 120-foot-thick layer of silt and clay separates Unit D from the uppermost well screen of the City of Shelton water supply wells completed in Unit F. Reclaimed water introduced into Unit A in the assessment area is not expected to migrate through Units B through E to reach the City of Shelton wells.

Subsequent storage studies for WRIA 14 may investigate whether groundwater storage projects potentially impact deeper hydrostratigraphic units.

Groundwater Occurrence

Groundwater occurs in all hydrostratigraphic units in the assessment area and ultimately derives from infiltration of precipitation falling inside and outside the assessment area. Groundwater levels, therefore, fluctuate with seasonal rainfall and with longer climate cycles. Infiltration within the assessment area recharges groundwater within shallow units. Low permeability units below Unit D impede vertical percolation of infiltration to deeper units. Molenaar and Noble (1970) concluded that deeper units are recharged by precipitation outside the assessment area that percolates downward into the deeper units and flows laterally into the assessment area. Isotopic analysis of groundwater samples collected from wells completed in deeper groundwater units support the conclusion that deeper units receive recharge from outside the immediate assessment and investigation areas (NWLW, 2005). Groundwater in Units A and B discharges into streams in the assessment area, whereas deeper groundwater in Units C and D and deeper units discharge into stream channels at elevations near sea level, or directly into Oakland Bay.

Unit A

The saturated portion of Unit A is a moderately to highly permeable, wide-ranging but locally discontinuous, unconfined aquifer. The depth to groundwater in Unit A ranges

from ground surface in wetland areas to more than 40 feet, where thick layers of the unit have accumulated in depressions or on slopes on top of Unit B. The saturated thickness of Unit A ranges from 5 to 30 feet thick, which typically fluctuates with seasonal groundwater elevations related to infiltration of precipitation. The thickest sections of Unit A occur in topographic depressions developed on the top of Unit B. Two significant depressions occur on either side of the east-west topographic ridge centered at Sanderson Field (**Figure 2.1**). The northern trough contains the upper Goldsborough Creek basin and extends easterly into upper Johns Creek basin near Johns Lake. The southern trough extends from the Mason County Fairgrounds area to the east beneath Wallace-Kneeland Road and Johns Prairie Road (**Figure 1.2**). Other depressions on top of Unit B and filled with significant thicknesses of Unit A are found west of Shelton at the sand and gravel quarry and at Johns Prairie at the Manke sand and gravel quarry (**Figure 2.1**).

Groundwater levels in Unit A fluctuate seasonally with precipitation that directly recharges Unit A. Groundwater levels in resource protection monitoring wells completed in Unit A at Sanderson Field, at Goose Lake and in the upper Goldsborough Creek basin fluctuate by 10 to 15 feet per year (CDM, 2003; GeoEngineers, 2004; Hong West, 1996). Groundwater levels at these wells reportedly respond rapidly to precipitation events, indicating relatively high groundwater recharge potential. NWLW (2005) also observed rapid groundwater level rise in the Unit A observation well instrumented in their investigation.

Unit A has a relatively high capacity to transmit groundwater through pore spaces in sand and gravel. Estimates of hydrogeologic conductivity values range from 0.001 to 1 cm/sec based on outcrop observations, well log data, infiltration testing during this assessment and technical reports. Parametrix (2000) reported a hydraulic conductivity value of 0.02 cm/sec for Unit A at McEwen Prairie northeast of Island Lake and a groundwater velocity ranging from 0.1 feet to several feet per day.

Regional groundwater flow data in Unit A has not been developed, but monitoring results from hazardous waste sites (for example, the Sanderson Field aerospace site and Goose Lake landfill site) generally indicate groundwater in Unit A flows in the direction of surface topography (GeoEngineers, 2004; CDM, 2003) and the topographic surface of underlying Unit B. **Figure 2.3** illustrates generalized groundwater flow directions in Unit A, based on surface topography and Unit B topography inferred from surface exposure, drilling logs and technical reports for the area. Groundwater flows generally towards lowlands, wetlands, lakes and streams. Robinson and Noble (1999) described groundwater divides within Unit A, which generally corresponded to locations where the topographic surface of Unit B was relatively high.

Groundwater in Unit A primarily discharges laterally to surface water bodies. The groundwater flux through the unit depends on saturated thickness and gradient, which varies substantially through the assessment area. For example, small seeps of groundwater were noted on steep slopes above Goose Lake. Shelton Springs, which emanates from Unit A, discharges on average 2,000 gpm (4.4 cfs) into Shelton Creek, north of Shelton. In contrast, low permeability Units B and C impede vertical seepage from Unit A and only a minor percentage of groundwater in Unit A discharges vertically downward into Units B and C, except where Unit A is locally thin or absent.

According to well log data and water rights records for the assessment area, groundwater use in Unit A is generally limited to irrigation and domestic supply, and well records indicate yields of 50 gpm. The unit likely is capable of much greater yield to wells. However, the rapid infiltration rates in the unit create a moderate to high risk for surface contamination from human activities, which limits the potable use of groundwater in Unit A. Deeper, more protected aquifers exist below Unit B and are used for potable supply. Most wells completed in Unit A are used for geotechnical or environmental monitoring (resource protection). Most existing wells completed in Unit A, therefore, are near areas of commercial development.

Units B and C

Unit B consists of dense layers of silt, sand and gravel, and Unit C consists primarily of fine sand and silt. Neither unit contains significant quantities of groundwater. Both units exhibit either confined or unconfined conditions. The depth to groundwater in Units B and C ranges from near ground surface in wetland areas to more than 30 feet. Groundwater monitoring data for Units B and C are essentially absent, but water levels likely fluctuate seasonally with precipitation. Groundwater in Units B and C likely flow in the direction of surface topography and discharge laterally to surface water bodies. Hydraulic conductivity values for different zones within Units B and C are expected to vary widely and likely range from 1×10^{-6} cm/sec to 1×10^{-2} cm/sec, based on field observation and drilling reports. Estimated groundwater velocity for Units B and C are expected to be less than 0.1 foot per day. The limited quantity of groundwater seeping downward into Unit D depends on Units B and C permeability and thickness. Thin, coarse-grained zones in Unit B transmit minor quantities of groundwater from Unit A to Unit C and D.

Coarser-grained layers within Unit B may contain sufficient storage for limited groundwater withdrawal for irrigation and domestic use. A few wells in the assessment area are completed in the unit (NWLW, 2005) and are not expected to yield more than 10 gpm.

Unit D

Unit D consists of an extensive layer of permeable sand and gravel which exhibits either unconfined or confined aquifer conditions, depending on the elevation and thickness of the unit, and the character of overlying units. The depth to groundwater in Unit D typically ranges from 30 to 100 feet, although groundwater levels may rise much higher in wells completed in confined portions of the unit. Where Unit D is exposed at the surface near Oakland Bay, groundwater may emanate from Unit D as springs.

Groundwater levels in Unit D fluctuate seasonally with precipitation although the response to precipitation is attenuated by the time delay for precipitation to infiltrate into the subsurface. Groundwater levels in domestic wells completed in Unit D east of Highway 101 near Island Lake fluctuate by several feet per year.

Unit D has a moderate to high capacity to transmit groundwater similar to that of Unit A. Estimates of hydrogeologic conductivity values based on water well log pumping data range from 0.001 to 0.1 cm/sec, and estimates of groundwater velocity ranges from 0.1 feet to several feet per day.

Groundwater elevation data generally indicate a southeasterly hydraulic gradient for Unit D towards Oakland Bay (NWLW, 2005). Horizontal hydraulic connection between discontinuous layers of Unit D and vertical connection with underlying units varies widely, and sufficient data are not yet available to trace actual groundwater flow paths within Unit D.

Well log data and water rights records for the assessment area indicate that Unit D is a significant source of domestic water supply in McEwen and Johns Prairies and near Island Lake, north and east of Shelton. **Appendix B** contains a map showing Group A and B wells in the assessment area, many of which are completed in Unit D. Unit D is the uppermost aquifer beneath low permeability Unit B, which protects groundwater in Unit D from surface contamination. Domestic well drillers, therefore, commonly target Unit D for domestic well completion. Wells typically yield 50 gpm but may attain 500 gpm (Molenaar and Noble, 1970).

Deeper Units

Deeper units below Unit D consist of layers of water-bearing sand and gravel and low permeability silt layers deposited during older glacial events, and mixed sand, silt, and gravel units deposited between glacial events. Water-bearing zones supply significant quantities of groundwater. The characterization of these units is limited to aquifer and well performance testing during well construction. Robinson and Noble (1999) evaluated hydrogeologic characteristics of City of Shelton supply wells completed in deeper aquifers. NWLW (2005) reviewed regional aquifer characteristics and hydrostratigraphic relationships for the deeper units.

In most of the assessment area, groundwater in the deeper units is hydraulically isolated from shallow units A, B, C and D by more than 100 feet of low permeability silt layers. Near the Oakland Bay shoreline, much of the shallower units have been eroded or were not deposited, and deeper units are either exposed at the surface or covered by thin layers of Unit A or Unit B. Deeper units receive recharge from sources outside the assessment area (Molenaar and Noble, 1970; NWLW, 2005), and groundwater discharges into marine water of Oakland Bay or Puget Sound.

Wells completed in these deeper units for municipal and industrial-commercial supplies withdraw have the capacity to withdraw up to 2,000 gpm from coarse-grained zones. The City of Shelton withdraws groundwater from wells completed at depths ranging from 200 to 700 feet bgs. Mason County, Washington Corrections Center (WCC), the Port of Shelton and Simpson (Rayonier) installed wells ranging from 300 to 700 feet deep into deeper units for domestic and industrial supply.

3. INFILTRATION AND STORAGE POTENTIAL OF THE ASSESSMENT AREA

This section describes the general infiltration and storage characteristics of the assessment area, which for this study was subdivided into seven distinct hydrogeologic regions that generally correspond to hydrologic sub-basins. The subdivisions represent areas where the local infiltration rates and storage capacity of Unit A could accommodate infiltration and storage projects. Each subdivision is related to a surface water body which would ultimately receive shallow groundwater discharging from the sub-basin. **Figure 3.1** illustrates the seven sub-basins. The infiltration sub-basins are bounded along the contact between permeable Unit A and relatively impermeable Unit B. The delineation of the infiltration sub-basins supports the selection of preferred locations for infiltration and storage projects in the assessment area.

Infiltration Rates

The infiltration rates for different regions of the storage assessment area are controlled by the porosity, layering (stratigraphy) and thickness of underlying geologic materials. The infiltration rates of each unit are not expected to differ substantially between sub-basins in the assessment area. However, because stratigraphy and thickness vary widely within a geologic unit, infiltration rates within a sub-basin may range by an order of magnitude, particularly near surface water bodies where alluvial processes have modified the hydrostratigraphic characteristics of the unit. Local testing is needed to characterize the infiltration rates at any prospective infiltration site.

Unit A

The long-term infiltration rate of outwash sand and gravel layers within Unit A is conservatively estimated at 2 inches per hour (in/hr). Higher rates likely occur within the assessment area. Estimated infiltration rates for alluvial sand and silt layers in Unit A are 0.1 to 1 in/hr. These are literature-based values typical for soils in the region (National Resources Conservation Service [NRCS] Soil Survey report for Mason County).

Units B and C

The estimated long-term infiltration rate for the glacial till and lacustrine materials of Units B and C is 0.01 in/hr (NRCS soil data), which is less than 1 to 10 percent of the infiltration rate of Unit A. Areas underlain by Units B and C are considered unsuitable for shallow infiltration and storage, unless the till is very thin and can be excavated to promote infiltration into underlying Unit D.

Unit D and Deeper Units

Surface exposures of Unit D and deeper hydrostratigraphic units in the assessment area are limited in extent. Infiltration rates for these deeper unconsolidated geologic units where they outcrop at the surface are estimated to range from 0.1 to 1 in/hr (NRCS soil data).

Relative Storage Capacity of Hydrogeologic Units

The groundwater storage capacity of the units within the assessment area depends on the porosity, saturated and unsaturated thickness, and areal extent.

Unit A

Much of Unit A has substantial capacity to store groundwater in open pore spaces of the coarse sand and gravel. Finer-grained layers of alluvial sediment along streams and near wetlands have less ability to store water. Unit A generally becomes thinner near streams and wetlands and near the surface contact with Unit B (e.g., the area north of Island Lake and east of Johns Lake). The areas of greatest Unit A thickness (30 to 100 feet) occur:

- between Island Lake and Shelton Springs;
- in the Johns Prairie region (also the site of several gravel pits);
- along Highway 102 between the Washington State Patrol Academy and Washington Corrections Center in the upper Goldsborough Creek sub-basin;
- near Mason County Fairgrounds; and
- west of Shelton near the confluence of Goldsborough Creek and Coffee Creek (also the site of several gravel pits).

Seasonal groundwater fluctuations of 5 to 20 feet in Unit A significantly control the amount of available storage in Unit A. Those areas with the greatest unit thickness have the greatest storage potential, where the unsaturated portion of Unit A above the seasonal high groundwater level exceeds 20 feet.

Units B and C

The dense, silty sand of and sandy silt of Units B and C have very little (less than 10 percent) porosity; therefore, little to no groundwater storage capacity, even in isolated, coarser layers.

Unit D

The storage capacity of Unit D depends on whether it is unconfined or confined below Unit B, and the thickness of the unit. Shallow unconfined sand and gravel layers within Unit D have moderate to high storage capacity, similar to that of Unit A. However, Unit D is generally not exposed at the surface and not readily accessible for surface infiltration to increase storage. Certain areas north of Sanderson Field near Johns Lake and near the WCC appear to have relatively thick unconfined sections of Unit D, which are thinly covered by Unit A or C. These areas potentially could accommodate shallow infiltration if low permeability surficial layers are removed to provide direct access to Unit D.

Deeper, hydraulically confined layers of Unit D have substantially lower storage capacity than unconfined zones, and may store additional water only under induced pumping pressures of artificial recharge wells. In the central portion of the assessment area near Island Lake, Unit D is used as the primary source of domestic water supply from private wells (**Appendix B**). This existing aquifer use would preclude storage projects within Unit D in this area. Future studies may evaluate the potential for successful aquifer storage and recharge (ASR) projects in WRIA 14.

Groundwater Mounding Potential

Groundwater storage in an aquifer increases when recharge exceeds discharge. Natural recharge of precipitation increases groundwater storage within Unit A during the rainy season, and groundwater storage declines as the water discharges to streams during the dry

season (**Figure 1.7**; see also Golder, 2003). Artificial infiltration of reclaimed water would locally increase aquifer storage beneath an infiltration and storage facility. Excessive infiltration could result in unacceptable groundwater level buildup (mounding) leading to surface ponding or diminished infiltration rates. The degree of groundwater mounding is controlled by the ability of the aquifer to transmit water away from the point of recharge. The aquifer hydraulic gradient (water table slope), hydraulic conductivity (permeability), and thickness equally affect the flow of water through an aquifer and associated groundwater mounding potential. Unacceptable groundwater mounding can be minimized by increasing and elongating the infiltration area and/or reducing the application rate to accommodate the aquifer conditions. Site characterization of potential infiltration and storage sites would include evaluation of these aquifer parameters to optimize infiltration system design.

Infiltration Sub-basin Characteristics

The assessment area was divided into infiltration sub-basins to compare local recharge and storage characteristics. This comparison will support the selection of potential infiltration and storage sites based on hydrogeologic characteristics and potential receptors of groundwater discharge (Section 6). **Table 3.1** summarizes the range of these characteristics within a sub-basin, and the location of surface water discharge. **Table 3.2** compares the characteristics for each sub-basin. **Figure 3.1** illustrates the boundaries of the sub-basins and the probable groundwater pathways and points of discharge for each sub-basin.

Table 3.1
Range of Infiltration and Storage Characteristics for the Storage Assessment Area

Range	Infiltration Rates (in/hr)	Groundwater Storage Capacity	Groundwater Mounding Potential
Low	< 0.1	Area < 25 acres Total Unit A Thickness < 20 ft	Hydraulic Conductivity < 0.1 cm/sec Hydraulic Gradient < 0.001
Moderate	0.1 to 10	Area 25 to 100 acres Total Unit A Thickness 20 to 40 ft	Hydraulic Conductivity = 0.1 to 1 cm/sec Hydraulic Gradient = 0.001 to 0.005
High	> 10	Area > 100 acres Total Unit A Thickness > 40 ft	Hydraulic Conductivity > 1 cm/sec Hydraulic Gradient > 0.005

Table 3.2
Comparison of Infiltration and Storage Characteristics for Storage Assessment Area
Infiltration Sub-Basins

Infiltration Sub-Basin	Infiltration Rates	Average Unit A Total Thickness	Relative Storage Capacity	Groundwater Mounding Potential	Surface Water Discharge
Upper Goldsborough Creek	High	20 to 70 feet	Moderate to High	Moderate	Upper Goldsborough Creek
Fairgrounds	High	20 to 40 feet	Moderate	Moderate	Lower Goldsborough Creek
Shelton	Moderate to High	10 to 40 feet	Low to Moderate	Moderate to High	Shelton Creek Wetlands
Upper Johns Creek	Moderate	10 to 30 feet	Low	Moderate to High	Upper Johns Creek
Lower Johns Creek	High	10 to 50 feet	Moderate to High	Low to Moderate	Lower Johns Creek
Johns Prairie South	High	20 to 50 feet	Moderate to High	Low	Oakland Bay
Lower Goldsborough Creek	Low	10 to 30 feet	Low to Moderate	Moderate	Lower Goldsborough Creek

4. REGIONAL WATER DEMAND

Water Budget of the Assessment Area

The water budget is the amount of water recharged, stored and discharged from the assessment area. Characterizing the water budget provides a basis for quantifying the potential benefits of a storage project and can be used to compare the current groundwater and surface water demand against the amount of reclaimed water that would be available under the Regional Plan.

Stored groundwater in Unit A will either accumulate or deplete from year to year depending on the balance between groundwater recharge from precipitation and discharge to the environment and to wells. Artificial increase in groundwater storage will change the natural water balance.

Precipitation entering the hydrogeologic system of the assessment area may follow several pathways. Precipitation may run off into surface water, infiltrate into the groundwater system, evaporates from soil and vegetation, or be used by vegetation for growth. Infiltrated precipitation may be withdrawn for beneficial uses, or ultimately discharge into surface water or Oakland Bay. Rainfall is distributed according to geologic and soil conditions and land use. The Level 1 Assessment analyzed water budgets for all hydrologic sub-basins of WRIA 14 (Golder, 2003). The study indicated that rainfall in the assessment area, on average, distributes equally into surface water runoff, groundwater recharge, and evapotranspiration. Because low permeability Unit B underlies most of the assessment area and reduces or limits deep percolation into lower units, most of the groundwater recharge occurs within Unit A, which temporarily stores the water until it discharges into wetlands, lakes, streams (Goldsborough, Shelton, and Johns Creeks), and Oakland Bay.

The hydrograph for Goldsborough Creek (Figure 1.7) indicates that stream flow patterns generally follow precipitation patterns; seasonal rise in stream flow matches seasonal increase in precipitation. Water level data for monitoring wells completed in Unit A at Sanderson Field and at Goose Lake (GeoEngineers, 2004) indicate rapid groundwater level rise in response to rainfall. Short-term fluctuations in surface water flow and groundwater levels, therefore, coincide with seasonal rainfall rates. Long-term fluctuations in rainfall due to episodic climatic variability such as El Niño and the Pacific Decadal Oscillation will affect long-term patterns in stream flow and groundwater levels.

The amount of runoff entering streams and the amount of precipitation entering groundwater systems in the sub-basins of these surface streams may be estimated using an annual rainfall of 65 inches, which is the average rainfall for Shelton and the storage assessment area (Western Regional Climate Center Data). Assuming one-third of 65 inches of rainfall infiltrates to groundwater, 22 inches or 1.8 feet of water infiltrates into each acre of land per year. If this water fills the 30 percent-pore space estimated for the typical unsaturated sand and gravel soil of Unit A, infiltrating precipitation would cause a groundwater level rise of approximately 6 feet. A 10- to 20-foot annual fluctuation in groundwater levels was observed in Unit A resource protection monitoring wells at Sanderson Field and Goose Lake hazardous waste sites, the Mason County closed landfill and the WCC sprayfield area (Hong West, 1996). The similarity in estimated recharge and water level response suggests that most infiltration entering shallow groundwater systems is temporarily (less than 5 years; based on distance to surface water) stored in Unit A and

then discharges to surface water; a minor portion of infiltrated water discharges into deeper units.

Water Demand in the Goldsborough Sub-Basin

Water use in the assessment area consists of instream flow, surface water diversion, and groundwater withdrawal. Water rights indicate the allocation of surface water to groundwater use and semi-quantify the actual use of water from these sources. The Level 1 Assessment summarized water rights for the entire WRIA 14. The Goldsborough Sub-Basin, which contains the assessment area, comprises 75 percent of all groundwater rights and 82 percent of all surface water rights in WRIA 14. More than 95 percent of these rights exist as certificate or permitted rights granted by the State of Washington. Unperfected, claimed rights comprise 5 percent of water rights in WRIA 14. Water in the assessment area is allocated predominantly for commercial, industrial, and municipal uses, and the source of water for this use derives equally from surface water and groundwater. Actual use of water for commercial and industrial purposes likely differs from permitted use, however.

Surface Water Rights and Actual Use

Table 4.1 summarizes the largest water rights that divert surface water and withdraw groundwater in the assessment area, and the location of withdrawal for each right. No applications for new surface withdrawal in the storage assessment area are currently filed with Ecology.

Surface water use includes commercial and industrial process-water diverted from the lower reach of Goldsborough Creek at the Simpson/Rayonier facilities (Ecology, 1983). Historically, the facilities have used less than 20 cfs of the water right. No current use data are available.

Groundwater Rights and Withdrawal

Figure 1.5 shows the wells associated with the largest certificated or permitted rights for groundwater withdrawal in the assessment area registered with Ecology. **Appendix B** identifies the locations of Group A and B wells in the assessment area. **Table 4.1** summarizes certificated and permitted rights and includes the depth of the point of withdrawal and the corresponding hydrogeologic unit. Significantly, all of the rights for the largest industrial and municipal supplies obtain groundwater from deeper hydrostratigraphic units. These deep groundwater zones are essentially isolated from Unit A in the assessment area. Shallow infiltration storage projects in Unit A, therefore, will not likely interfere with the primary groundwater withdrawals in the assessment area.

Table 4.1 also shows the six pending applications filed with Ecology for groundwater withdrawal in the assessment area. The applications represent an increase of approximately 600 ac-ft/yr, or 2 percent of the current certificated and permitted groundwater right.

Table 4.1
Largest Water Rights and Applications in the Assessment Area

Groundwater Right Holder	Point of Withdrawal	Quantity	Use
Simpson	Deeper Units	4,500 gpm 2,100 gpm 1,300 gpm 1,100 gpm	Commercial Industrial
Rayonier	Deeper Units	3,000 gpm 100 gpm	Commercial Industrial Irrigation
City of Shelton	Deeper Units	3,000 gpm 2,000 gpm 1,200 gpm	Municipal
Oak Park Water Co	Deeper Units	500 gpm 210 gpm	Domestic multiple
WCC	Deeper Units	1,126 140 gpm	Domestic multiple
WSP	Deeper Units	340 gpm	Domestic multiple
Surface Water Right Holder	Point of Withdrawal	Quantity	Use
City of Shelton	Shelton Springs	5 cfs	Domestic Multiple
Simpson	Goldsborough Cr	30 cfs 5.5 cfs 5 cfs	Commercial Industrial
Simpson/Rayonier	Goldsborough Cr	20 cfs	Commercial Industrial
Miles	Goldsborough Cr	15 cfs	Trust Water
Water Right Applicant	Point of Withdrawal	Quantity	Use
WCC	Groundwater	1,126 gpm	Domestic multiple
WCC	Groundwater	660 gpm	Domestic multiple
Port of Shelton	Groundwater	300 gpm	Commercial Industrial
Port of Shelton	Groundwater	85 gpm	Commercial Industrial Irrigation
Port of Shelton	Groundwater	240 gpm	Commercial Industrial Irrigation
Washington Water Service	Groundwater	50 gpm	Domestic multiple

More than 150 domestic and small public system supply wells are recorded with Ecology for the area surrounding Island Lake. **Appendix B** shows the locations of public Group A and Group B water supply wells and corresponding wellhead protection areas in the storage assessment area. More than 85 percent of these wells are completed between depths of 60 and 150 feet, which corresponds to Unit D. These wells are broadly distributed in the region east of Highway 101. Siting a reclaimed water infiltration facility in many areas east of Highway 101 would likely encounter public opposition, even though the potential to impair the use of Unit D groundwater is low, as the aquifer is protected by overlying low permeability Units B and C.

Instream flow regulations and stream closures

Instream flow regulations were established to prevent surface water diversion during critical portions of the year, reserving the natural flow for habitat and environmental quality of the watershed. Goldsborough Creek, Johns Creek and Shelton Creek have instream flow restrictions and are closed to consumptive uses during dry season closure periods (WAC 173-514). The minimum instream flow for Goldsborough and Johns Creek ranges from 45 to 85 cfs and from 7 to 45 cfs, respectively. For comparison, 0.6 MGD (the maximum discharge of reclaimed water under the Regional Plan) is 0.93 cfs.

Summary

Groundwater supply for the largest users in the assessment area derives from deep sources not hydraulically connected to shallow Unit A. Surface water diversions and typical flows in streams exceed 10 cfs. In comparison, the 0.93 cfs of reclaimed water generated by the Regional Plan is small relative to local demands for groundwater and surface water. However, introducing 0.93 cfs flow of reclaimed water to the environment is a measurable benefit to increase stream flow or offset groundwater demand.

5. BENEFICIAL USES AND POTENTIAL IMPACTS OF INFILTRATION AND STORAGE

Potential Benefits of using Reclaimed Water for Groundwater Storage in Unit A

Potential benefits to infiltration and storage of reclaimed water in Unit A include increased baseflow discharge to streams (augmentation), improvement of wetland function and using reclaimed water to offset impacts of groundwater withdrawal.

Stream Augmentation and Wetland Improvement

Applying reclaimed water to the subsurface will increase groundwater storage in Unit A and likely increase the baseflow to those streams hydraulically connected to Unit A. The amount and timing of baseflow increase will depend on the application rate and the distance to the surface water body. Increasing the baseflow would change the natural stream hydrograph, benefiting those streams by augmenting stream flows that have been artificially reduced by diversion of precipitation recharge from surface activities (e.g., impervious surfaces, stormwater management) or by groundwater withdrawal.

Goldsborough and Johns Creek both support riparian habitat and are salmon-bearing streams whose flow may have been impacted by development in upland areas and/or groundwater withdrawals. These streams would benefit from increased flow. Shelton Creek is more urbanized than Goldsborough and Johns Creek, and is not a significant salmon stream (Ecology, 1983).

Under the Regional Plan, maximum stream augmentation rate is equal to the application rate, up to 0.6 MGD or 0.93 cfs. In comparison, the seasonal flow in Goldsborough and Johns Creeks range from 25 to 250 cfs, and 7.5 to 75 cfs, respectively. Stream augmentation would increase baseflow during the dry season by 4 percent in Goldsborough Creek and 12 percent in Johns Creek. The small increase will not impair the natural conditions of typical low season flow, and could offset declines in stream flow from other direct or indirect diversion of surface water.

Wetlands could benefit from increased groundwater levels that would stabilize water levels and improve water quality in the wetland areas, as long as excessive seepage rates were managed to avoid wetland function impairment. The broad wetlands in the upper Johns Creek basin may be either impaired or benefited by the addition of Class A water in the system depending on the hydrologic conditions of a particular area that may receive the water or the type of benefit. Increasing the hydrologic input to the wetland may exacerbate flooded areas, and actually impair stream quality by creating a larger source of solar heated water discharging from the wetlands into streams. Conversely, where urbanization has reduced recharge to wetlands, the addition of Class A water to the subsurface may improve or stabilize wetland function.

Offset Groundwater Withdrawal

Using reclaimed water for commercial, industrial and irrigation uses and reducing the demand for groundwater would potentially benefit natural systems impaired by groundwater withdrawal. Most groundwater withdrawals in the assessment area derive from deeper groundwater sources that are not hydraulically connected to streams. For example, the City of Shelton wells tap deep water bearing units at depths below sea level, which are not expected to have any significant impact on stream flow. Groundwater withdrawal and stream flow in the Johns Prairie area is currently under evaluation by the Squaxin Tribe.

Preliminary findings indicate some correlation between groundwater withdrawal and stream flow (NWLW, 2005; Squaxin Tribe, personal communication). Reducing groundwater demand from Units D and deeper aquifers above sea level in the Johns Prairie area may benefit stream flow in Johns Creek.

Washington law recognizes and encourages the beneficial use of reclaimed water in water right planning and delivery. Chapter 90.46 RCW states:

If the proposed use or uses of reclaimed water are intended to augment or replace potable water supplies or create the potential for the development of additional potable water supplies, such use or uses shall be considered in the development of the regional water supply plan or plans addressing potable water supply service by multiple water purveyors. The owner of a wastewater treatment facility that proposes to reclaim water shall be included as a participant in the development of such regional water supply plan or plans.

Aquifer Storage and Recovery

Reclaimed water stored in the subsurface is available for later withdrawal and reuse. The Regional Plan could generate as much as 663 acre-feet of reclaimed water per year. The proportion of water that may be stored in each sub-basin and available for recovery would depend on the total available storage volume of the sub-basin, and the rate of discharge to surface water. Areas where the sub-basins are large, thick, and porous have the greatest potential for storage and recovery. This potential decreases where the aquifer is highly permeable and rapidly discharges the reclaimed water into a nearby surface water receptor or deeper aquifer, for example, near upper Johns Creeks where Unit A appears relatively thin and in potential hydraulic connection with underlying Unit D (NWLW, 2005). Those sub-basins where Unit A has the greatest total and unsaturated aquifer thickness and storage potential include Upper Goldsborough Creek, Lower Johns Creek, Johns Prairie South and the Fairground sub-basins (**Figure 3.1**).

The owner of a wastewater treatment facility that is reclaiming water with a permit issued under this chapter has the exclusive right to any reclaimed water generated by the wastewater treatment facility. Use and distribution of the reclaimed water by the owner of the wastewater treatment facility is exempt from certain water right permit requirements. Revenues derived from the reclaimed water facility shall be used only to offset the cost of operation of the wastewater utility fund or other applicable source of system-wide funding.

Chapter 90.46 guarantees the rights to control and use reclaimed water to the generator:

The owner of a wastewater treatment facility that is reclaiming water with a permit issued under this chapter has the exclusive right to any reclaimed water generated by the wastewater treatment facility. Use and distribution of the reclaimed water by the owner of the wastewater treatment facility is exempt from the permit requirements of RCW 90.03.250 and 90.44.060.

The right to recover stored reclaimed water may be considered as a criterion for selecting an infiltration and storage facility. If the reclaimed water rapidly enters and mixes with a regional groundwater system, it may be difficult to distinguish the stored water from existing groundwater, which may already have an associated groundwater right. The selection process will need to weigh their alternative options whether to promote introducing the

reclaimed water to the environment for beneficial uses or to store the water in the subsurface for subsequent removal and reuse.

Reclaimed water may be immediately withdrawn for non-potable uses. The depth to water in Unit A is typically too shallow for a supply well sanitary seal, and the Department of Health would not likely permit recovery of reclaimed water in Unit A for drinking water uses, even if the water resides in the subsurface for more than one year. Intended use of reclaimed water withdrawn will constrain the location of an infiltration site.

Potential Impacts of using Reclaimed Water for Groundwater Storage in Unit A

Potential impacts from infiltration and storage of reclaimed water relate to adverse effects of increased water levels on natural systems, adverse impacts to groundwater quality that affect water supplies or natural groundwater or surface water systems, reduction of water recharge if existing wastewater systems cease operation, or impacts that impair functions of existing land uses or critical areas.

Wetlands

Direct discharge of reclaimed water to wetlands or disturbance of wetland soil or vegetation is not considered in this evaluation; any infiltration and storage facility would be constructed more than 150 feet from any wetland area designated under Mason County CAO. **Appendix C** contains a map showing some of the critical wetlands identified by Mason County.

Subsurface infiltration near a wetland could potentially affect the wetland condition and would require evaluation of these impacts or a minimum setback to avoid impact to wetland function. Hydraulic loading restrictions will depend on the normal seasonal fluctuation of the wetland, which may tolerate substantial seasonal fluctuations. For example, monitoring data at the Goose Lake landfill site documented more than 10 feet of seasonal water level rise in Goose Lake.

Under Chapter 90.46 RCW, artificially-induced water level rise in the wetland cannot exceed 10 centimeters per month above normal fluctuations, and cannot exceed 2 to 3 centimeters per day. Selection of an infiltration and storage site must include the hydrogeologic characterization of Unit A to assess potential changes of wetland water levels. A broadly distributed infiltration system setback at least 500 feet from the nearest wetland likely would mitigate these potential impacts.

Slope Stability

Infiltration near steep slopes potentially could saturate and weaken the stability of soil in the slope faces. Although engineering controls on the slope face could mitigate slope erosion due to seepage, the infiltration facility should have a minimum 500-foot setback from slopes. This setback could vary, depending on the infiltration facility distribution design, the discharge rate, Unit A thickness and slope geometry.

Potential Interference with Existing Water Supply Wells

Increased groundwater storage under the Regional Plan will locally change the groundwater elevation and flow regime of Unit A. Only a few water supply wells are completed in shallow Unit A in the assessment area, and these wells are used for domestic (irrigation) purposes.

RCW 90.46 requires a 500-foot setback, which will provide adequate protection for potential water quality impacts to existing water supply wells. The City of Shelton established

wellhead protection areas (WHPAs) around the City's water supply wells and Shelton Springs north of town. The City wells are completed in aquifers deeper than Unit D. The WHPAs indicate the area of potential recharge to the wells and springs, and extend 1 to 2 miles around the wells and springs, but do not extend west of Highway 101. Reclaimed water infiltrating into the assessment area potentially would not impact the City wells unless a significant portion of the flow percolates through Units B, C and D into the completion zone for the City wells. Intervening hydrostratigraphic units between Unit A and deeper water supply aquifers significantly reduces the possibility for deep vertical migration of reclaimed water from Unit A.

Shelton Springs emanates from the contact between Unit A and Unit B. Robinson and Noble (1999) indicated that the recharge area for the springs extends to the northwest and potentially includes Goose Lake, a distance of 1 mile. Reclaimed water infiltrated south of Sanderson Field potentially will enter the capture zone for the springs and discharge at Shelton Springs. However, significant filtering, mixing, and dilution would occur along the 1-mile flow path from Goose Lake to Shelton Springs.

Few water supply wells withdraw groundwater in the assessment area west of Highway 101 (except at the WCC) that would restrict the location of the infiltration facility. Numerous relatively shallow domestic supply wells completed in Unit D east of Highway 101 potentially would constrain the location of infiltration and storage facility. Even though Units B and C would impede flow of reclaimed water into Unit D, public acceptance of a reclaimed water infiltration close to domestic wells is unlikely.

Potential Impact to Downstream Rights

The owner of the wastewater treatment facility must complete a water right self-assessment to determine whether recovery of reclaimed water currently discharged to groundwater or cessation of current wastewater discharge to groundwater would impair existing downstream rights. The owner must:

- a. identify downstream water rights;
- b. identify downstream beneficial uses;
- c. identify hydrologic impacts to beneficial uses;
- d. notify general public and specific downstream right holders;
- e. hold public meetings/hearings at utility's discretion; and
- f. formulate any necessary mitigation (or enhancement) proposal to respond to identified impacts.

The Regional Plan would collect wastewater from the WCC, Washington State Patrol Academy (WSPA), and Port of Shelton, which currently discharge in onsite sewage systems. Water flow in Goldsborough Creek potentially may decrease by the amount of wastewater effluent currently discharged into the WCC and WSPA sewage systems. Water flow in Shelton Creek potentially may decrease by the amount of wastewater effluent currently discharged into the Port of Shelton sewage system. Downstream rights would include instream flow requirements for Goldsborough Creek, and withdrawals from Shelton Creek-shallow groundwater system (e.g., Shelton Springs). These are the most likely locations where the loss of wastewater discharge could impair existing rights.

Regulatory Requirements for Reclaimed Water

Ecology regulates reclaimed water discharge to the environment under Chapter 90.46 RCW. Setback distances and locations for application are based on the quality and the intended use of the reclaimed water, the distance to adjacent land uses, the method of discharge of reclaimed water, and the environmental sensitivity of potential receptors.

“To assure public health and environmental protection, proponents of reclaimed water projects must submit a reclaimed water engineering report, conduct a water rights impairment self assessment, and obtain a reclaimed water permit.”

The satellite WWTP plant is expected to initially generate 0.3 MGD of Class A reclaimed water and may reach a maximum rate of 0.6 MGD. The actual discharge rate to the environment will fluctuate seasonally with the amount of reclaimed water generated and the demand for any consumptive use of reuse water. Long-term demand for commercial or industrial use and seasonal demand for irrigation use of reclaimed water will decrease the amount of water released for temporary storage.

Water Quality and Intended Use Requirements

Chapter 90.46 establishes acceptable uses of reclaimed water depending on water quality. The satellite plant will generate Class A water, suitable for all water uses except human consumption. Class A reclaimed water intended for groundwater recharge must receive additional treatment to remove nitrogen (Chapter 90.46). The reclaimed water quality must meet the groundwater quality criteria downgradient of the facility, so that the quality of the reclaimed water shall fully protect public health and the water quality of the waters of the state.

Setback Restrictions for Reclaimed Water

Chapter 90.46 establishes setback requirements to protect certain types of land or water uses from mitigate contact with reclaimed water. Table 3 in Chapter 90.46 establishes minimum distances (setbacks) to protect existing land uses. For subsurface infiltration of Class A reclaimed water, the only setback required by Chapter 90.46 is that the minimum distance between the infiltration area and a potable water supply well is 50 feet. Fewer supply wells exist west of Highway 101 compared to east of Highway 101. Setback requirements for reclaimed water will not significantly restrict locating infiltration sites west of Highway 101.

Mason County Critical Area Ordinances

Mason County regulates activities in areas identified with critical or sensitive environmental conditions. These include areas of groundwater recharge, slope stability, and wetlands.

Critical Aquifer Recharge Areas

Mason County has established Critical Aquifer Recharge Areas (CARAs) to protect potential groundwater supplies from contamination by surface releases of hazardous or toxic materials (Mason County Resource Ordinance 17.01.080). Mason County CARA regulations follow Ecology's *Guidance Document for the Establishment of Critical Aquifer Recharge Area Ordinances, Publication 97-30* (Ecology, 2000). Mason County identified all surface exposures of Unit A as a Class 1 CARA – Extremely Susceptible (for outwash thickness greater than 25 feet) or Class 2 CARA – Highly Susceptible (for outwash thickness less than 25 feet). The designation is intended to protect sources of drinking water, although shallow groundwater in Unit A is not used for potable supply, and likely would not be used because of shallow depth to water. **Appendix C** contains a map of the Critical Aquifer Recharge Areas.

Infiltration and storage of reclaimed water from a municipal treatment facility source is not prohibited in the Mason County CARA. However, a Mason County Environmental Permit would be required to meet requirements to construct and operate a facility in the CARA.

Critical Landslide Areas

Mason County has identified areas of landslide hazards with greater than 15 percent slopes. A 500-foot setback is required for any activities that could reduce slope stability. Siting an infiltration and storage facility would require analysis of the potential risk to slope failure due to increased soil moisture. **Appendix C** contains a map of the Critical Landslide Areas. The slopes near Goose Lake and in lower Johns Creek are mapped as Critical Landslide Areas.

Critical Wetlands

Mason County CAO requires a permit for any activities that may involve or result in a significant physical or chemical change in wetlands water sources. There are wetlands in each of the infiltration sub-basins, and siting an infiltration and storage facility would require analysis of the potential change. Identification and mapping of critical wetlands in Mason County is incomplete. **Appendix C** contains a map of some, but not all, critical wetland areas in the storage assessment area.

Hazardous Waste Sites

Under the Toxics Cleanup Program, Ecology regulates the remediation and monitoring of hazardous waste sites. Infiltration and storage projects potentially could affect the groundwater and surface water system near these sites and interfere with cleanup objectives and monitoring plans.

Three significant hazardous waste sites in the assessment area are located west of Highway 101: the closed Mason County landfill, the Port of Shelton former aerospace facility, and the Goose Lake Landfill site. **Figure 1.5** shows these site locations. Resource protection wells at these facilities are used to monitor groundwater elevations and water quality in Unit A. Subsurface infiltration upgradient of these facilities potentially could change groundwater levels and groundwater flow directions, and interfere with monitoring, assessment, and remediation of these sites. A 500-foot upgradient setback and a 100-foot downgradient setback would buffer the potential impacts of infiltration at these sites. Evaluation of potential changes to groundwater elevations would be required to determine the minimum setback for a site near the hazardous waste sites to minimize potential impacts to the site remediation objectives.

Land Zoning

Local government ordinances for certain land use activities constrain the siting and operation of an infiltration and storage facility through exclusion or setback limitations. For example, the Port of Shelton (pers. comm.) requires a 500-foot setback for activities that create open water near Sanderson Field in order to limit the potential to attract birds into the airport flight path. Other setbacks to protect existing land uses would be addressed during the permitting process.

UIC Regulation

Ecology manages federal regulations for underground injection control (UIC). Reclaimed water applied to the subsurface in a perforated pipe would be considered a Class V injection well under Chapter 173-218 Underground Injection Control Program. If the reclaimed

water project meets the requirements of RCW 90.46, then the injection well would only require registration and not require a state waste discharge permit.

6. EVALUATION OF INFILTRATION AND STORAGE AT ALTERNATE SITES

The preceding sections indicate that several sub-basins within the storage assessment area have hydrogeologic characteristics with sufficient infiltration rates, storage capacity and acceptable groundwater mounding potential to accommodate up to 0.6 MGD of Class A water from the Regional Plan reclaimed water project. The Fairgrounds, Shelton Creek and Lower Goldsborough Creek sub-basins (**Figure 3.1**) near the satellite WWTP could accommodate the projected reclaimed water discharge and provide additional opportunities for reuse and beneficial use. Selecting a more distant alternate site would increase the cost to pipe the reclaimed water to the alternate location. Therefore, the potential benefits of discharging the water to an alternate location must exceed the benefits of discharging the reclaimed water to a closer location.

Table 6.1 summarizes advantages and disadvantages to siting the reclaimed water infiltration and storage facility for the Regional Plan for different infiltration sub-basins in the assessment area. Reuse of reclaimed water anywhere in the assessment area would reduce groundwater demand, and is therefore not considered a unique advantage for a particular infiltration sub-basin.

Table 6.1
Comparison of Advantages and Disadvantages for Reclaimed Water Infiltration at Each Infiltration Sub-Basin

Infiltration Sub-Basin	Significant Characteristics	Advantages	Disadvantages
Upper Goldsborough Creek	Distance to satellite plant		Distant
	Augments salmon-bearing stream or improves wetland function	Yes	
	Infiltration and storage capacity	Substantial	
	Potential Impacts	Low population density Low density of domestic & public wells	
Fairgrounds	Distance to satellite plant	Nearby	
	Augments salmon-bearing stream or improves wetland function	Yes	
	Infiltration and storage capacity	Adequate	
	Potential Impacts	Low population density Low density of domestic & public wells	
Shelton	Distance to satellite plant	Nearby	
	Augments salmon-bearing stream or improves wetland function	Yes (Goose Lake wetlands)	No (Shelton Creek)
	Infiltration and storage capacity	Substantial	
	Potential Impacts		Goose Lake Hazardous Waste Site Goose Lake Wetlands High density of domestic & public wells Moderate to high population density

Table 6.1 (continued)
Comparison of Advantages and Disadvantages between Infiltration Sub-Basins

Upper Johns Creek	Distance to satellite plant		Distant
	Augments salmon-bearing stream or improves wetland function	Yes	Increase flow into wetland may increase temperatures in Johns Creek
	Infiltration and storage capacity		Limited
	Potential Impacts		Johns Creek Wetlands Moderate population density Moderate density of domestic & public wells
Lower Johns Creek	Distance to satellite plant		Distant
	Augments salmon-bearing stream or improves wetland function	Yes	
	Infiltration and storage capacity	Substantial	
	Potential Impacts		Landslide Potential along lower Johns Creek Moderate population density Moderate density of domestic & public wells
Johns Prairie South	Distance to satellite plant		Distant
	Augments salmon-bearing stream or improves wetland function		No
	Infiltration and storage capacity	Substantial	
	Potential Impacts	Low population density	Moderate density of domestic & public wells
Lower Goldsborough Creek	Distance to satellite plant	Moderate	
	Augments salmon-bearing stream or improves wetland function	Yes	
	Infiltration and storage capacity	Limited	
	Potential Impacts	Low density of domestic & public wells	Potentially unstable slopes at gravel pit. Current sand and gravel mining.

Review of the comparison table suggests that the Regional Plan should not consider upper Johns Creek and the south Johns Prairie infiltration sub-basins for reclaimed water infiltration and storage; the disadvantages far outweigh any advantages for siting the Regional Plan infiltration and storage facility. These areas, however, still have adequate infiltration and storage capacity for other local reclaimed water projects including stormwater reuse.

The other five sub-basins offer specific advantages to site a reclaimed water facility for the Regional Plan. The upper Goldsborough Creek sub-basin offers the greatest area for siting an infiltration and storage project, although at a moderate distance from the satellite facility. Reuse opportunities exist at the WCC, WSPA and the Port of Shelton. The lower Johns Creek sub-basin offers a location that would directly benefit Johns Creek by augmenting stream flow, and reuse opportunities may exist or be developed along the distribution line from the satellite WWTP and Johns Prairie. The Fairgrounds sub-basin and the Shelton sub-basin near Sanderson Field-area are next to the satellite treatment plant location. Reuse opportunities exist at the County Fairgrounds and the Port of Shelton, and Goose Lake wetlands could receive additional recharge. Although the lower Goldsborough Creek sub-basin offers limited area for infiltration and presents potential impacts to slope stability and roads, it may still be considered, as it is downhill from the satellite WWTP, would augment Goldsborough Creek, has limited land use and offers reuse opportunities at the Shelton Memorial Park.

The Sanderson Field-Fairgrounds area and the Port of Shelton Industrial Park were considered the two areas with highest potential benefits from reclaimed water discharge. Infiltration and aquifer testing results confirmed both the high infiltration rates and limited groundwater mounding potential for these areas (**Appendix A**). Additional evaluation of the infiltration and groundwater mounding potential of the Upper Goldsborough Creek sub-basin was recently completed and is presented in **Appendix D**. The evaluation indicated favorable conditions and benefits for reclaimed water infiltration and storage at the WCC sprayfield area.

Comparison of Two Preferred Areas

Sanderson Field – Fairgrounds Area

The satellite treatment plant is near the boundary between the Fairgrounds and the Shelton infiltration sub-basins (**Figure 3.1**). Reclaimed water applied near the southeast corner of Sanderson Field would enter Unit A, discharge toward Goose Lake and ultimately into Shelton Creek. Reclaimed water applied near the fairgrounds would enter Unit A and discharge towards the west and ultimately into Goldsborough Creek. The latter option would potentially augment a salmon-bearing stream but would not likely affect significant wetlands such as those surrounding Goose Lake, and it would not interfere with the remedial actions at the Goose Lake landfill site. This site offers abundant terrain and opportunities to benefit multiple uses. An infiltration system could straddle both areas, providing benefits to both Goldsborough Creek and Goose Lake wetlands. The access road into the Fairgrounds and level ground at Sanderson Field provide ready access for construction with few underground utilities.

Port of Shelton Industrial Park

Reclaimed water applied at the Port of Shelton Industrial Park would enter Unit A and discharge ultimately into Johns Creek, augmenting stream flow. Reuse of water at the ball

fields would offset groundwater withdrawal from Port of Shelton wells. The terrain is relatively cleared and flat, facilitating construction, although underground utilities are widespread. Transmitting the reclaimed water to this location, however, would require greater engineering design for the traverse of roads, highways and streams.

Fate of reclaimed water

Reclaimed water infiltrated at the two sites would follow groundwater pathways according to the aquifer hydraulic gradient and hydraulic conductivity. The travel time for reclaimed water to reach a point of discharge depends on the length of the flow path, which will vary according to the various points of infiltration and discharge. Average groundwater velocity in Unit A at the Goose Lake hazardous waste site is estimated at approximately 3 to 30 feet per day (GeoEngineers, 2004). Similar travel times are estimated for the Industrial Park area based on studies by Parametrix and this study.

The reclaimed water will mix with groundwater along the groundwater flowpath. The fate of the reclaimed water depends on the duration and completeness of the mixing process, and the chemical differences between the reclaimed water and groundwater. The Class A reclaimed water chemistry would not substantially differ from groundwater in Unit A, although the water would be warmer, less oxygenated and potentially contain more dissolved solids than groundwater. These groundwater velocity estimates can be used to guide the location of the reclaimed water application area to allow for adequate mixing before discharge into surface water. Assuming a 10 foot-per-day groundwater velocity, infiltrated reclaimed water would reach a surface water body 2,000 feet away (e.g., Goose Lake, Goldsborough Creek, Johns Creek) within 200 days, or approximately 6 months. Under this scenario, water infiltrated during the wet season would reach the surface water point of discharge during the dry season. Redirecting reclaimed water for reuse during summer months would allow the infiltration receptor beneath the recharge facility to recover in anticipation of the wet season. A flexible system design with multiple discharge pathways would permit optimal management strategies for multiple benefits.

Comparison of Potential Benefits and Impacts

Table 6.2 summarizes the potential benefits and impacts from the infiltration of reclaimed water at the two preferred sites:

Table 6.2
Comparison Potential Benefits and Impacts between Preferred Sites

Potential Benefit and Assumptions	Sanderson Field- Fairgrounds	Industrial Park
Instream flow enhancement	Up to 0.6 MGD (0.93 cfs) to Goldsborough Creek. <i>Timing of enhancement will depend on location, rate and timing of infiltration.</i>	Up to 0.6 MGD (0.93 cfs) to Johns Creek. <i>Timing of enhancement will depend on location, rate and timing of infiltration.</i>
Reduction in groundwater demand from current withdrawal	Groundwater demand could decrease by 0.6 MGD. <i>Reclaimed water is either diverted or recovered and used to replace groundwater.</i> <i>Cost effectiveness depends on distance between reclaimed water source and point of use.</i>	Same
Improvement of environmental quality at current discharge sites	Reduction in up to 0.6 MGD of on-site sewage effluent discharged to shallow groundwater. <i>No impairment to current benefit of sewage discharge on local water balance.</i>	Same
Wetland stabilization	Controlled discharge to wetlands would stabilize wetland water levels and improve wetland habitat at Goose Lake.	Same for wetlands along Johns Creek.

Table 6.2 (continued)
Comparison Potential Benefits and Impacts between Preferred Sites

Potential Impact and Mitigation	Sanderson Field- Fairgrounds	Industrial Park
Impairment to hazardous waste site	Change in groundwater gradient at Goose Lake could affect current remedial plan. <i>Apply water in broad distribution area to minimize local water table rise.</i>	No known hazardous waste near site.
Nearby wetlands	Application rate should not cause 2 to 5 cm/day increase in wetland water level. <i>Apply water in broad distribution area to minimize local water table rise.</i> <i>Meter water at critical times to avoid significant rise in wetland water level.</i>	Same.
Slope stability	No areas designated as critical slopes within 500 feet of application area. Seepage may occur along toe of slope above Goose Lake. <i>Avoid application within 500 feet of slope.</i>	Same for critical slopes along lower Johns Creek.
Water supply wells	No water supply wells exist within 500 feet of the site.	Class A water reclaimed water could enter poor sanitary seals of existing groundwater supply wells. <i>Apply reclaimed water no closer than 500 feet of the Port of Shelton supply well.</i>

Reclaimed Water Facility Permitting Requirements

Constructing and operating a reclaimed water facility would be regulated by Ecology and DOH under 90.46 RCW and would be included in the owner's subsequent comprehensive sewer and water plans. At a minimum, permitting would include the following:

- Engineering Report – describes the design and operation of the facility.
- Reclaimed Water Use Permit – describes the facility, the sources of wastewater, the characteristics of reclaimed water, intended uses of reclaimed water, surrounding land use and hydrogeologic characteristics, and confirms compliance and monitoring requirements. The owner must declare the intent to recover (not abandon) reclaimed water discharged to the environment.

- Water Right Impairment Analysis – describes the potential impacts (and mitigation) of the reclaimed water project on downstream rights.

Reclaimed Water Facility Implementation and Operation

Design and operation of the reclaimed water infiltration facility will depend on the subsurface characteristics of the area selected for the infiltration. Subsurface infiltration trenches, rather than open ponds, to apply water to Unit A likely would provide the greatest operational control and flexibility, lowest potential for groundwater mounding, and greatest potential for public acceptance. The infiltration system would consist of underground piping laid in trenches backfilled with drain rock to facilitate hydraulic connection with the subsurface. The system could either be pressurized or gravity-controlled, depending on the topography and stratigraphy of the area. The system must be accessible for periodic maintenance. The network of piping and trenches could be constructed to meet the initial loading rate and then expand as loading increased or with changes in groundwater storage beneath the facility.

Infiltration testing results at the two test sites indicate the range of infiltration trench requirements to accommodate the 0.3 to 0.6 MGD (208 to 416 gpm) of reclaimed water from the satellite WWTP. The infiltration rate at the test location of the Sanderson Field-Fairgrounds area was 16 gpm for an 80-square-foot trench, or approximately 0.2 gpm per square foot of trench. Approximately 600 to 1,200 feet of 2-foot-wide trench would be required to infiltrate the 0.3 to 0.6 MGD of reclaimed water at the testing location. However, test pit exploration along the Fairground road encountered little of the organic-rich soil observed at the infiltration test location, and the permeability of the soil at most areas at the Sanderson Field-Fairgrounds area is likely 2 to 10 times greater than at the test site, based on observed lithology in the test pits. Also, the organic-rich layer is less than 5-feet thick, and may be removed during construction to promote rapid infiltration in the constructed infiltration system. The potential infiltration system requirement for the Sanderson Field-Fairgrounds area is estimated at 200 to 500 feet in length.

The infiltration rate at the test location of the Port of Shelton Industrial Park at Johns Prairie area was 115 gpm for a 40-square-foot trench, or 2.9 gpm per square foot of trench. Approximately 35 to 70 feet of 2-foot-wide trench would be required to infiltrate the 0.3 to 0.6 MGD of reclaimed water at the Industrial Park test location. This value likely underestimates the trench requirement because of the extraordinarily high infiltration rate observed. The potential infiltration system requirement for the Port of Shelton Industrial Park area is estimated at 100 to 300 feet in length.

The range of estimated infiltration trench requirements between the two sites demonstrates the effect soil permeability has on the design of the infiltration system. Subsurface exploration using test pits and shallow borings would confirm hydrostratigraphy of the application area to support design and construction, and identify areas underlain by organic-rich soil that would be removed during construction. The layering of Unit A beneath the Johns Prairie Industrial Park likely varies widely, due to complex glacial and alluvial processes in this area. Exploration would identify high permeability gravel channels and low permeability silt barriers that potentially would direct groundwater flow in unexpected directions.

Groundwater monitoring wells and surface water (stream and wetland) monitoring stations upgradient and downgradient of the infiltration system would support the permitting

requirements for water quality and elevation monitoring to confirm technical performance and environmental compliance. Installing and monitoring these stations at least 6 to 12 months in advance of system design would provide actual environmental data that would substantially improve the infiltration system performance.

A pilot infiltration test is recommended at the selected site to confirm the performance of the proposed system. The pilot test should consist of up to one week of infiltration testing at the maximum application rate, preferably during the period when groundwater and surface water levels are at maximum levels. The pilot test would include periodic groundwater, surface water level and quality monitoring to assess the hydraulic and geochemical response of the groundwater-surface water system to the infiltration of reclaimed water.

During the design of the infiltration system, it is recommended to include additional reserve areas for expansion of the infiltration system. This additional area could be used to meet greater demand and provide greater amount of storage. It is also recommended that the system design include additional infiltration trenches to allow rotation into and out of active and dormant trenches. Designing a portion of the system to periodically lie dormant will promote dissipation of groundwater mounding and provide flexibility for system maintenance.

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